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Distribution patterns and diversity of invertebrates of temperate rainforests in Tasmania with a focus on Pauropoda

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Abstract

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Pauropoda are recorded for the first time from Tasmania. Nineteen species are listed from a large collection of specimens made during an intensive survey of temperate rainforest in Tasmania. A key is provided for the identification of Tasmanian species which are recorded by voucher number and the biogeographical affinities of the fauna are discussed. Taxic richness of Pauropoda in Tasmanian rainforests is compared with that of several other groups of litter and bark invertebrates from the same collections. All groups show similar patterns of high taxic richness in the northwest and southeast regions with lower richness at higher altitudes. The implications for the conservation of Tasmania's highly endemic invertebrate fauna is discussed.

Keywords Acarina, Amphipoda, Diplopoda, Isopoda, Opiliones, Symphyla, regional diversity, conservation priorities.

Introduction

The Pauropoda is a Class of minute Arthropoda belonging to the Subphylum, Myriapoda. It comprises around 700 hundred species worldwide that are grouped into five families. The total world fauna is likely to be in the region of 5000 species as many regions and ecosystems are under-collected (Scheller, 1990). Adults have eight to eleven pairs of legs, lack eyes and are either white or lightly sclerotised with a maximum length of about 1.5 mm (Scheller, 1990). Pauropoda tend to be soil-living but are also found in rotting logs, under bark and in moss and leaf litter. They are generally most abundant in moist soils that have high levels of organic matter. Their feeding habits vary; some groups feed on fungi and decaying organic matter while others may consume more solid food (Scheller, 1990).

Although Pauropoda have been found in humid soils under native vegetation as well as on agricultural land throughout the Australian continent, very little is known of the composition of the fauna. They are particularly species-rich and abundant in forest soils but a soil sample from under any native vegetation is likely to contain some specimens. Such data as exist indicate that there is a very high level of species endemism of probably over 90%. Moreover, there are likely to be 20 to 30 species belonging to five or so genera within a single vegetation type (Postle et al., 1991). This is the same order of magnitude as found in the central Amazon forest where over 50 species were recorded from a single vegetation type (Scheller, 1994, 1997). The Australian fauna is estimated to comprise at least 1000 species of which only 18 species (2%) have been recorded so far. Previous records are from Queensland (Remy, 1959), New South Wales (Harrison, 1914), Victoria (Tiegs, 1943, 1947; Remy, 1949), Northern Territory (Greenslade and Mott, 1979) and Western Australia (Remy, 1957; Postle et al., 1991). A checklist for Australia is available (ABRS, ABIF, 2002). No species of pauropod have been recorded previously for Tasmania.

Although pauropods occur under both native vegetation and crops, densities are variable. In studies overseas, densities of pauropods of up to several thousand have been found in soils (Adis et al., 1999; Hågvar and Scheller, 1998; Lagerlöf and Scheller, 1989) and, on a site in Denmark, they were more abundant than Psocoptera, Coleoptera and Symphyla, and a quarter as abundant as Acarina (Hågvar and Scheller, 1998). Similar densities have been found at some sites in Australia, indicating that they comprise a significant part (5% of individuals) of the arthropod fauna (Greenslade and Mott, 1979). Abundances are reduced by fire (Broza and Izhaki, 1997).

The invertebrate biodiversity of cool temperate rainforest was sampled intensively and extensively in Tasmania as part of the National Rainforest Conservation Program (NRCP) (Coy et

al., 1993). This forest type occupies just under 600,000 hectares in Tasmania and represents 10% of the state. It is most prominent in northwestern Tasmania, with other less extensive areas in the northeast and on the east coast and occasional patches in the southwest. The survey sampled 19 localities covering all the nature conservation regions of the state accepted at the time (1990) and major rainforest types with the aim of documenting the invertebrate fauna comprehensively, identifying areas of greatest species richness and phyletic diversity and assessing impacts on the fauna (Coy et al., 1993). It was the first documentation of the invertebrate fauna within a major vegetation type in Tasmania and the first to assess the conservation status of this highly endemic and species-rich fauna. The data also provided a basis for comparison with other forest faunas within and outside Tasmania for groups that were targeted.

Listed are the Pauropoda species collected during the survey. An estimated 142,000 specimens of invertebrates were collected, among them 1087 (0.8%) Pauropoda. No earlier publications record specimens from Australian *Nothofagus* forests. Nineteen species were found in the survey, of which 17 are new. Keys to families, genera, subgenera and species are presented. Pauropod biodiversity at each locality is compared with that of other invertebrate groups from the same survey and the data used to make inferences regarding the conservation value of each region of Tasmania.

Materials and Methods.

Twelve sites covering each of the conservation regions accepted at that time (1990) in which rainforest occurred, and representing the four main rainforest communities: Callidendrous, Thamnic, Implicate and Open Montane forest, were selected for intensive sampling. The sampling was stratified so that there were two replicates in each region and two to three replicates of each of the four rainforest types. The sites are listed below (*Locs 1–12*). Besides the 12 major sites, some collecting was carried out in supplementary sites (*Locs 13–19*). On each of the 12 main sites the same sampling methods were used; Tullgren funnel extraction of soil, moss and leaf litter, pitfall trapping, yellow pan trapping, sweeping, hand collections and pyrethrin knockdown of tree trunks (PKD) (Coy et al., 1993). Only Tullgren funnel extraction of leaf litter and humus was done on the supplementary sites. Pauropods were found most abundantly in funnel extractions of soil cores, moss and litter, although a few specimens were collected by other methods. Sampling was carried out in a single season – autumn for the most part. All specimens were preserved in ethanol. Detailed descriptions of the localities are given in the NRCP report (Coy et al., 1993).

Holotypes of the species to be described in a later publication (Scheller, in prep), will be lodged in the Australian National Insect Collection and paratypes and other material in the Queen Victoria Museum.

Abbreviations

Collectors: ATW, A.Trumbull-Ward; DR, D. Rounsevell; HM, H. Mitchell; JD, J. Diggle; MN, M. Neyland; PG, P. Greenslade; RC, R. Coy; SS, S. Smith.

Collecting sites as given in Coy et al. (1993).

Loc. 1 = NRCP 1 NW Tasmania, Savage River (41°19.1'S, 145°16.2'E and 41°18.5'S, 145°16.3'E), callidendrous *Nothofagus cunninghamii* rainforest, alt. 500 m (Grid Reference CQ558,247 and CQ560,255). Conservation status: Forest Reserve, part of the "Savage River Pipeline Corridor".

Loc. 2 = NRCP 2, NW Tasmania, Bradshaws Road (41°49.9'S, 145°37.0'E), callidendrous and thamnic *Nothofagus cunninghamii* rainforest, alt. 840 m (Grid Reference CP854,680). Conservation status: Mt Murchison River Reserve.

Loc. 3 = NRCP 3, central Tasmania, Projection Bluff (41°43.1'S, 146°43.5'E), high altitude callidendrous rainforest dominated by *Nothofagus cunninghamii*, alt. 1100 m (Grid Reference DP770,812). Conservation status: World Heritage Area.

Loc. 4 = NRCP 4, NW Tasmania, Cradle Mountain campground (41°35.4'S, 145°55.9'E), high altitude callidendrous rainforest dominated by *Nothofagus cunninghamii*, alt. 880 m (Grid Reference DP109,955). Conservation status: part conservation area.

Loc. 5 = NRCP 5, NE Tasmania, Mt Victoria (41°20.4'S, 147°49.9'E), callidendrous *Nothofagus cunninghamii* forest, alt. 900 m (Grid Reference EQ693,233). Conservation status: forest reserve.

Loc. 6 = NRCP 6, NE Tasmania, Mt Michael (41°10.9'S, 148°00.4'S), heavily logged callidendrous *Nothofagus cunninghamii* rainforest, alt. 740 m (Grid Reference EQ845,406). Conservation status: blue tier forest reserve.

Loc. 7 = NRCP 7, SE Tasmania, Big Sassy Creek, (42°08.5'S, 147°54.3'E), small strip of *Atherosperma moschatum* dominated callidendrous rainforest along the creek, alt. 400 m (Grid Reference EP749,332). Conservation status: forest reserve.

Loc. 8 = NRCP 8, SE Tasmania, Sandspit River (42°42.1'S, 147°51.5'E), mixed *Eucalyptus regnans* and *Atherosperma moschatum* callidendrous forest, alt. 180 m (Grid Reference EN703,713). Conservation status: forest reserve.

Loc. 9 = NRCP 9, SW Tasmania, Frodshams Pass (42°49.7'S, 146°22.9'E), callidendrous/thamnic and implicate rainforest dominated by *Nothofagus cunninghamii*, alt. 620 m (Grid Reference DN497,580). Conservation status: World Heritage Area.

Loc. 10 = NRCP 10, SW Tasmania, Mt Field, below Lake Fenton (42°40.9'S,146°37.5'E), open montane low canopy *Nothofagus gunnii* forest, alt. 980 m (Grid Reference DN695,746). Conservation status: national park.

Loc. 11 = NRCP 11, SE Tasmania, Tasman Peninsula (43°08.2'S, 147°54.5'E), small remnant of callidendrous-thamnic intermediate cloud forest dominated by *Nothofagus cunninghamii* remains within an eucalypt dominated forest, mixed forest, alt. 400 m (Grid Reference EN742, 346). Conservation status: not reserved.

Loc. 12 = NRCP 12, SE Tasmania, Mt Mangana, Bruny I (43°22.1'S, 147°17.0'E), low-canopy callidendrous-thamnic intermediate rainforest dominated by *Nothofagus cunninghamii* on Mt Mangana, alt. 540 m (Grid Reference EM229, 980). Conservation status: forest reserve.

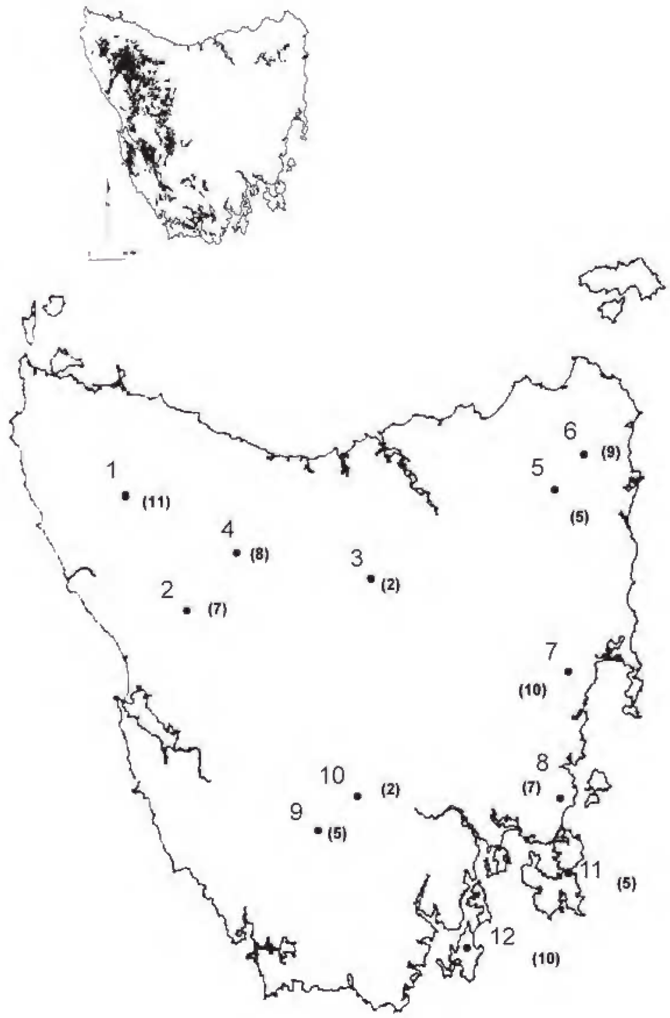

Figure 1. Location of collecting sites, numbered from *1* to *12* as in the text. Numbers in brackets indicate total number of pauropod species found on each site. Insert shows distribution of rainforest in Tasmania taken from Coy et al. (1991).

Loc. 13 = NW Tasmania, Hibbs Lagoon (42°34'S, 145°19.5'E), rainforest (Grid Reference CN623, 853). Conservation status: South West Conservation Area.

Loc. 14 = N Tasmania, Mt Stronach (41°10'S, 147°34'E), rainforest (Grid Reference EQ476, 422). Conservation status: forest reserve.

Loc. 15 = N Tasmania, Asbestos Ranges (41°09'S, 146°40'E), North Leg, rainforest (Grid Reference DQ727, 444). Conservation status: national park.

Loc. 16 = SW Tasmania, Riveaux Creek (43°10'S, 146°38.6'E), Huon pine rainforest (Grid Reference DN704, 205). Conservation status: World Heritage Area.

Loc. 17 = NE Tasmania, Simons Road (41°21.5'S, 147°31.3'E), (Grid Reference EQ435, 212). Conservation status: special forestry management zone for springtails.

Loc. 18 = N Tasmania, Saxons Creek (41°15'S, 146°40'E), rainforest (Grid Reference DQ751, 316). Conservation status: not reserved.

Loc. 19 = SW Tasmania, Old Farm Road, Mt Wellington, (42°54'S, 147°16'E), *Eucalyptus* forest. Conservation status: national park.

Checklist and distributions of Tasmanian Pauropoda

Regions: NW – northwest, NE – northeast, N – north, C – central, SE – southeast, SW – southwest

Family Pauropodidae

Genus *Allopauropus* s.str.

Subgenus *Allopauropus* Silvestri, 1902

Type species: *Allopauropus brevisetus* Silvestri, 1902

Allopauropus (*Allopauropus*) sp. nov. 1 .... NW, NE, SE, SW

Allopauropus. (*Allopauropus*) sp. nov. 2 .... SE

Subgenus Decapauropus Remy, 1931

Type species: *Allopauropus* (D.) *cuenoti* (Remy)
Decapauropus cuenoti Remy, 1931

Allopauropus (*Decapauropus*) sp. nov. 3 .... SE, NW, SW, N

Allopauropus (*Decapauropus*) sp. nov. 4 .... NW, SE

Allopauropus (*Decapauropus*) sp. nov. 5 .... SW

Allopauropus (*Decapauropus*) sp. nov. 6 .... NW

Allopauropus (*Decapauropus*) sp. nov. 7 .... NW, SE

Allopauropus (*Decapauropus*) sp. nov. 8 .... NW, NE, SW

Genus *Cauvetauropus* Remy, 1952

Type species: *Cauvetauropus microchaetus* (Remy, 1952)
Allopauropus microchaetus Remy, 1948

Subgenus *Nesopauropus* Scheller, 1997

Type species: *Cauvetauropus* (*Nesopauropus*) *biglobulosus* Scheller, 1997

Cauvetauropus (*Nesopauropus*) sp. nov. 9 .... NE

Genus *Stylopauropoides* Remy, 1956

Type species: *Stylopauropoides tiegsi* (Remy, 1949)

Stylopauropoides ringueleti Remy, 1962 .... NW, N, SW

Stylopauropoides sp. nov. 11 .... NW, NE, SE, N

Stylopauropoides sp. nov. 12 .... NW, NE, SE, SW

Stylopauropoides sp. nov. 13 .... NW, SE, C, NE, SW

Stylopauropoides sp. nov. 14 .... NW, C, NE, SE, SW

Stylopauropoides sp. nov. 15 .... NW, NE, SE

Stylopauropoides sp. nov. 16 .... NW

Genus *Pauropus* Lubbock, 1867

Type species: *Pauropus huxleyi* Lubbock, 1867

Pauropus dolosus Remy, 1956 .... SE

Pauropus sp. nov. 18 .... NW, NE, SE, SW

Brachypauropodidae

Genus *Brachypauropoides* Remy, 1952

Type species: *Brachypauropoides pistillifer* Remy 1952

Brachypauropoides sp. nov. 19 .... NW, NE, SE

Key to Tasmanian Pauropoda

1. Body fusiform; tergites entire, generally not distinctly ; legs longer than length of segment .... Pauropodidae 2

   Body oval, somewhat flattened; tergites most often divided, generally distinctly sclerotized; legs equal to or shorter than length of segment .... Brachypauropodidae

2. All legs 5-segmented .... *Cauvetauropus*

   First and last pair of legs 5-segmented, all other legs 6-segmented 3

3. Anterior margin of sternal antennal branch nearly always distinctly shorter than posterior margin ... *Allopauropus* 5

   Anterior and posterior margins of sternal antennal branch nearly always of subequal length 4

4. Pygidial sternum with setae b1 + b2 .... *Pauropus* 19

   Pygidial sternum with setae b1 only .... *Stylopauropoides* 13

5. Pygidial sternum with setae b1 and b2 only .... *A.* (*Decapauropus*) 8

   Pygidial sternum with setae b1 and b2 and b3 .... *A.* (*Allopauropus*) s. str 6

6. Temporal organs without anterior appendage; distal part of T3 cylindrical; anal plate with straight posterior margin .... *A.* (*A.*) sp. 1

   Temporal organs with distinct anterior appendage; T3 with ovoid distal swelling; anal plate with long posteromedian process .... *A.* (*A.*) sp. 2

8. Antennal globulus g not as wide as maximum diameter of tergal branch t 9

   Antennal globulus g wider than maximum diameter of tergal branch t .... *A.* (*D.*) sp. 8

9. Distal swelling on T3 absent 10

   Distal swelling on T3 present .... *A.* (*D.*) sp. 6

10. Posterior margin of anal plate incised 11

    Posterior margin of anal plate rounded .... *A.* (*D.*) sp. 3

11. Seta on coxa of last pair of legs furcate; T3 with simple pubescent hairs 12

    Seta on coxa of last pair of legs simple; T3 with branched pubescent hairs .... *A.* (*D.*) sp. 5

12. Appendage of collum segment incised anteriorly; proximal 2/3 of T3 thickened .... *A.* (*D.*) sp. 4

Appendage of collum segment pointed anteriorly; T3 with thin axes ..... *A.* (*D.*) sp. 7

13. Branches of anal plate separated by V-shaped incision 14

 Branches of anal plate separated by U-shaped incision ..... *S.* sp. 16.

14. Lateral appendages on anal plate absent 15

 Lateral triangular appendages on anal plate distinct ..... *S.* 13

15. Distal appendages of anal plate with flat posterior surface 16

 Distal appendages of anal plate with convex posterior surface ..... *S.* sp. 14

16. Anteriodistal and posteriodistal corners of sternal antennal branch equally truncate; pygidial b1 evenly curved 17

 Posteriodistal corner of sternal antennal branch distinctly more truncate than anteriodistal one, pygidial b1 undulate ..... *S.* sp. 11

17. T3 with long simple branches or with branched pubescence; setae on tergites fine 18

 T3 with very simple pubescence hairs; setae on tergites and head clavate ..... *S.* sp. 15

18. Distal part of all trichobothria except for T5 with simple curved pubescent branches; st cylindrical blunt ... *S.* sp. 10

 Distal part of all trichobothria without branches except T5 but with branched pubescent hairs; st thin, tapering, pointed ..... *S.* sp.12

19. Pygidial st subcylindrical tapering; posterior appendages of anal plate short and blunt ..... *P. dolosus*

 Pygidial st similar to a knife blade; posterior appendages of anal plate long, thin and pointed ..... *P.* sp. 18

Discussion

Composition and affinities. In Tasmania, as elsewhere, the Pauropodidae is the most diverse family as all but one of 19 species belong to it. Of its five subfamilies, only the Pauropodinae is present, already known to be the most widespread and most species rich subfamily worldwide. The Tasmanian rainforest fauna is relatively rich in species, but unexpectedly no species in the family Eurypauropodidae was collected. This is a widely distributed family with representatives in Borneo, New Guinea and New Caledonia and on mainland Australia (New South Wales). The family is also found in cooler localities in Great Britain and Central Europe, northern USA and at over 2000 m in the Himalayas (Scheller, 1990 and included references).

The majority of the NRCP specimens belong to two genera, *Allopauropus* with eight species and *Stylopauropoides* with seven species, together comprising 80% of the species. Postle et al. (1991) found 39 species in forests in south Western Australia but over a longer period. Of these 31 (80%) belonged to either *Stylopauropoides* or *Allopauropus*. As here, a large proportion of the fauna was undescribed as only two species were already named. *Allopauropus* is near cosmopolitan and the most widespread and most diverse genus of pauropods with nearly 200 species known worldwide, so the high number of *Allopauropus* species in Australia is not surprising.

The genus *Stylopauropoides* has its main distribution in the southern hemisphere and is not often encountered in the north. Its southerly range indicates a Gondwanan origin and its absence from the southern part of Africa may be a result of lack of collecting. Thirteen species have been described but only one from north of the equator (Ivory Coast and Guinea). A list of species in the genus with their distributions is given in Table 1. The six new species from Tasmania suggests a high concentration of species in this genus in Tasmanian rainforests.

Pauropus also occurs worldwide hence is considered near cosmopolitan as well. The other genera, *Cauvetauropus* and *Brachypauropoides,* have wide but more southerly distributions. Only ten species have been described in *Cauvetauropus,* but they are distributed over a very large area from Brazil, France, north and tropical Africa, the Seychelles and Sri Lanka. The same is true of *Brachypauropoides,* now known from Madagascar, Borneo and New Zealand.

Affinities are strong between Tasmania and New Zealand. As noted above for Tasmanian rainforest, the genus *Stylopauropoides* – with nearly 40% of total species and 57% of total specimens collected – is well represented. The genus is also diverse and abundant in New Zealand where six species have been described (Remy,1952, 1956a, 1956b), one of which is also known from mainland Australia (Remy, 1949). In another New Zealand collection, 106 pauropods were studied in which *Stylopauropoides* represented 35% of the species and 74% of the specimens (Remy, 1952, 1956a, 1956b). Although collecting methods and vegetation in the two surveys differed, the results indicate that the genus is particularly diverse in these two regions. Other similarities with New Zealand are in the genera *Brachypauropoides* and *Pauropus*. The former was known previously from Madagascar, Borneo and New Zealand, and the Tasmanian species is close to one of the two New Zealand species, *B. pistillifer* Remy. *Pauropus dolosus* is common to New Zealand and Tasmania and *A.* sp. 1 is close to *A. maoriorum* Remy from New Zealand.

In conclusion the Tasmanian rainforest fauna is rich in species but of low generic diversity, and affinities are strongest at the species and generic level with New Zealand as might be expected (Kantvilas et al., 1985).

Habitats. The Tasmanian collections recorded pauropods from tree trunks (5 species) and tree ferns (1 species) for the first time. Both habitats were sampled by pyrethrin knock-down. Numerous specimens of several species (15 species, 71 records) were collected from moss on sites where they were not common in other habitats. In rainforest, moss commonly has a higher moisture content which may account for higher species richness here.

Abundance. Species varied in numbers of specimens caught from one individual to over 200. Seven species were represented

Table 1. List of known species in the genus *Stylopauropoides* with their distributions.In addition six new species from Tasmania are recorded in this paper.

Species	**Localities**	**References**
1. S. tiegsi (Remy)	Australia (eastern)	Remy 1949
	New Zealand	Remy 1952c, 1956a, 1956b
2. *S. bornemisszai* Remy	Australia (western)	Remy 1957,
		Postle *et al.* 1991
3. *S. ringueleti* Remy	Argentina	Remy 1962
	Chile	Scheller 1968
	Tasmania	New record
4. *S. lambda* Remy	New Zealand	Remy 1956b
5. *S. subantarcticus* Scheller	Crozet Islands	Scheller 1974
6. *S. infidus* (Remy)	New Zealand	Remy 1956a
7. *S. duplex* (Remy)	New Zealand	Remy1956a
8. *S. bilobatus* Scheller	New Caledonia	Scheller 1993
9. *S. hirtus* (Remy)	New Zealand	Remy 1952c, 1956a
10. *S. delamarei* (Remy)	Ivory Coast	Remy 1948
	Guinea	Remy 1959a
11. *S. vadoni* (Remy)	Madagascar	Remy1956c,
		Remy & Bello 1960
12. *S. incisus Remy & Bello*	Madagascar	Remy & Bello 1960
13. *S. furcillatus* (Remy)	New Zealand	Remy 1952c
	New Caledonia	Scheller 1993

by fewer than 20 individuals (37%), eight species represented by between 21 and 99 individuals (42%) and four species (21%) represented by over 100 individuals. There was a distinct trend for the most numerous species to be the most widespread, as expected.

Regional distribution. Because the NRCP material comes almost exclusively from rainforests (fig. 1), species occurrence in other vegetation types is not known. Within rainforests, most species were found to be distributed widely in the state being recorded from all major regions (table. 2). Seven species were widely distributed: A. sp.1, A. sp. 3, S. sp. 11, S. sp. 12, and P. sp. 18, were found in four regions and S. sp. 13 and S. sp. 14 in five regions. Two other species, S. sp. 15 and S. sp. 19 seem to have more northerly and easterly distributions; two, A. sp. 8 and *S. ringueleti*, were most commonly found in the northern and southwest regions, and two species recorded from both northwest and southeast regions, A. sp. 4 and A. sp. 7. Six species, A. sp. 2, A. sp. 5, A. sp. 6, , C. sp.9, S. sp. 16 and *P. dolosus* were only found at a single site and may be short range endemics. This is a high proportion (30%) of rare species although it is also possible that some of these species at least are have a preference for other vegetation types such as eucalypt forest.

Regional diversity. Faith (1992) described a method of ranking sites based on phyletic diversity in which branch lengths on a phylogenetically derived tree of relationships were used as a measure of divergence and hence conservation uniqueness. Faith and Greenslade (1994) provided a preliminary analysis of three groups of invertebrates from the NRCP sites which indicated that the northwestern sites (*Locs 1*, *2* and *4*) were major contributors to phyletic diversity. Although phylogenetic trees are not available for any of the groups (except for Triaenonychidae Opiliones (Hunt, 1996), new taxonomic information is available for three more groups. In the absence of relationship trees, the data are used to calculate the simple measure of ”taxic” diversity for six groups; Diplopoda (R. Mesibov, unpublished data), Opiliones (G. Hunt, unpublished data), euptyctime oribatid mites (Niebala and Colloff, 1997), Amphipoda (A. Friend, unpublished data) and Isopoda (A. Green, unpublished data) in addition to the Pauropoda (tables 1

Table 2. Records of Pauropoda species from NRCP sites with total species, subgenera, genera, families and taxic score for each site

Species	Sites													Number of records	
	1	2	3	4	5	6	7	8	9	10	11	12	Other sites	Main sites	Other sites
Allopauropus sp. nov. 1	+	+		+		+	+					+	13,16	6	2
Allopauropus sp. nov. 2							+	+				+		3	0
Allopauropus sp. nov. 3		+					+	+			+	+	13,16,18,19	5	4
Allopauropus sp. nov. 4				+			+				+	+		4	0
Allopauropus sp. nov. 5													16	0	1
Allopauropus sp. nov. 6	+													1	0
Allopauropus sp. nov. 7				+								+		2	0
Allopauropus sp. nov. 8	+				+				+					3	0
Cauvetauropus sp. nov. 9						+								1	0
Stylopauropoides ringueleti Remy, 1962		+											14,15,19	1	3
Stylopauropoides sp. nov. 11	+	+		+	+	+	+				+		17, 18	7	2
Stylopauropoides sp. nov. 12	+			+	+	+	+		+			+	13.16,17	7	3
Stylopauropoides sp. nov. 13	+		+	+		+	+	+	+		+	+	13,17,19	9	3
Stylopauropoides sp. nov. 14	+	+	+	+	+	+	+	+	+	+		+		11	0
Stylopauropoides sp. nov. 15	+			+	+	+	+						17	5	1
Stylopauropoides sp. nov. 16	+												13	1	1
Pauropus dolosus Remy, 1956								+			+	+		3	0
Pauropus sp. nov. 18	+	+				+		+	+	+		+	13,17	7	2
Brachypauropoides sp. nov. 19	+	+				+	+	+					13,17	5	2
Total species	11	7	2	8	5	9	10	7	5	2	5	10			
Total subgenera	5	5	1	3	2	5	4	5	2	2	3	4			
Total genera	4	4	1	2	2	5	3	4	3	2	3	3			
Total families	2	2	1	1	1	2	2	2	1	1	1	1			
TAXIC SCORE	22	18	5	14	10	21	19	18	11	7	12	18			

and 2). These groups include a variety of decomposer groups and a predatory and scavenger group (Opiliones) and were selected partly on the basis that they were characteristic of rainforest faunas and also because they showed a negative response to disturbance (Coy et al., 1993; Greenslade, 1992); hence they could act as surrogates for the whole rainforest fauna. They were also the only groups for which all species identifications were available. There were some differences in the total number of species found in each higher taxon with Opiliones being the largest group with 34 species, followed by euptyctime oribatid Acarina with 31, Diplopoda with 29, Isopoda with 28, Pauropoda with 19 and Amphipoda with 17. The appendix lists species identified from the collections. The larger numbers of euptyctime oribatid Acarina, Diplopoda and Opilione species compared with smaller detritivores such as Pauropoda, may be a characteristic of rainforest faunas.

Table 2 summarises the site record data for all 19 species of pauropod. The number of species, subgenera, genera and families at each of the main twelve localities is given and these figures summed, without weighting, to give an simple overall ”taxic” richness”. This method gives more weight to the phylogenetic diversity found on each site than does a simple species richness count and is used here because of the absence of any formal phylogenetic analysis. The collecting intensity

Table 3. Numbers of species, genera, families and total taxic score of Pauropoda, euptyctime oribatid mites (Niebala and Colloff, 1997), Opiliones (G. Hunt, pers. comm.), Diplopoda (R. Mesibov, pers. comm.), Amphipoda (A. Friend, pers. comm.) and Isopoda (A. Green, pers. comm.) recorded on each of the twelve main NRCP sites during the survey.

Taxa		Sites											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Pauropoda	**species**	11	7	2	8	5	9	10	7	5	2	5	10
	genera	4	4	1	2	2	5	3	4	3	2	3	3
	families	2	2	1	1	1	2	2	2	1	1	1	1
	Taxic diversity	17	13	4	11	8	16	15	13	9	5	9	14
Oribatid mites	**species**	17	12	4	0	6	3	8	6	6	4	10	15
	genera	3	5	3	0	3	2	3	3	2	2	3	4
	families	2	3	2	0	1	1	2	2	1	1	2	2
	Taxic diversity	22	20	9	0	10	6	13	11	9	7	15	21
Opiliones	**species**	11	12	1	1	12	10	7	10	4	1	3	8
	genera	6	9	1	1	10	7	6	9	2	1	2	6
	families	3	3	1	1	3	3	2	2	2	1	1	3
	Taxic diversity	20	24	3	3	25	20	15	21	8	3	6	17
Diplopoda	**species**	9	6	0	2	6	2	6	4	2	2	3	5
	genera	6	5	0	2	5	2	5	4	1	1	3	4
	families	3	2	0	2	1	2	4	4	1	1	2	3
	Taxic diversity	18	13	0	6	12	6	15	12	4	4	8	12
Amphipoda	**species**	5	4	0	0	0	0	0	1	2	0	2	6
	genera	4	4	0	0	0	0	0	1	2	0	2	5
	families	1	1	0	0	0	0	0	1	1	0	1	1
	Taxic diversity	10	9	0	0	0	0	0	3	5	0	5	12
Isopoda	**species**	12	9	1	7	6	4	5	7	5	3	6	7
	genera	5	5	1	3	3	2	4	4	2	1	3	3
	families	4	4	1	2	2	2	3	3	2	1	3	3
	Taxic diversity	21	18	3	12	11	8	12	14	9	5	12	13
Total taxic diversity		**108**	**97**	**19**	**32**	**66**	**56**	**70**	**74**	**44**	**24**	**55**	**89**
Site ranking		**1**	**2**	**12**	**10**	**6**	**7**	**5**	**4**	**9**	**11**	**8**	**3**

was identical at all the 12 main sites so providing a solid basis for comparison. The data indicates that the Savage River site (NW *Loc. 1*) is the most taxic rich site followed by Mt Michael (NE, *Loc. 6*) and Big Sassy Creek (SE, *Loc. 7*). Three other sites (NW *Loc. 2*, SE *Loc. 8* and SE *Loc. 12*) all have an equal score so high taxic richness appears to be spread over all regions except for the southwest and central north.

Total taxic richness for the five other groups and a mean ranking for all sites is shown together with the pauropod data in tables 3 and 4. There is a tendency for all the groups to show similar patterns of species richness between localities as that shown by the pauropods. Localities from the northwest and southeast (1, 2, 6, 7 and 12) have consistently high rankings for all six invertebrate groups while localities 3, 4, 9 and 10 are consistently low. The same pattern was found when the taxic diversity was calculated using a weighting system (not shown). Apart from Frodshams Pass (9), the other three sites with low scores are all high altitude rainforest (over 880m). Overall there is a trend of decreasing taxic diversity with altitude for all sites with a significant negative correlation of taxic diversity with altitude of $r = -.61$, $p<0.05$. This finding is not surprising given the sparser tree cover resulting in more open vegetation and, presumably, higher dessication rates at the higher altitudes. Although montane vegetation types were not present at Frodshams Pass, it was located at a high altitude and three types of rainforest were sampled rather than only the more common Calledendrous type, which may be the reason for its low species richness.

The Symphyla which were also studied from these collections (Clarke and Greenslade, 1996) also showed a higher species richness from localities *1* and *2* in the northwest than *7* to *9* and *11* and *12*. Material from sites *3* to *6* and *10* were not studied so this taxon has not been included here.

Factors affecting the taxic diversity, apart from altitude, rainforest type or region could be annual rainfall, area of

Table 4. Individual and mean rankings of taxic scores of selected invertebrates from the twelve main rainforest sites

Sites	Pauropoda		Oribatid Acari		Opiliones		Diplopoda		Amphipoda		Isopoda				
	Taxic diversity	Ranking	Taxic diversity	Ranking	Taxic diversity	Ranking	Taxic diversity	Ranking	Taxic diversity	Ranking	Taxic diversity	Ranking	Summed ranks	**Mean rank**	**Final rank based on summed ranks**
1	17	1	22	1	20	4	18	1	10	2	21	1	10	**2**	**1**
2	13	5	20	3	24	2	13	3	9	3	18	2	18	**3**	**2**
3	4	12	9	8	3	10	0	12	0	7	3	12	61	**10**	**12**
4	11	7	0	12	3	10	6	9	0	7	12	5	50	**8**	**10**
5	16	2	13	5	15	7	15	2	0	7	12	5	29	**5**	**5**
6	16	2	6	11	20	4	6	8	0	7	8	10	42	**7**	**8**
7	15	3	13	5	15	7	15	2	0	7	12	5	29	**5**	**5**
8	13	5	11	6	21	3	12	4	3	6	14	3	27	**5**	**4**
9	8	10	9	8	6	8	4	10	5	4	9	9	49	**8**	**9**
10	5	11	7	10	3	10	4	10	0	7	5	11	59	**10**	**11**
11	9	8	15	4	6	8	8	7	5	4	12	5	36	**6**	**7**
12	14	4	21	2	17	6	12	4	12	1	13	4	21	**4**	**3**

rainforest or conditions during collection. Highest rainfall is recorded from high altitude localities as well as in the extreme northwest and east, while lowest rainfall occurs in the southeast. It does not appear that average rainfall is influencing taxic richness. It should be noted, however, that rain fell heavily during sampling at *Loc. 2* and fauna was particularly active at this site during collection.

The similarity shown by the different invertebrate groups gives the taxic pattern more validity than that from a single group. Moreover, the large number of species (158), genera (67) and families (20) as well as higher groups (six) contributing to the patterns, add to its significance. These results demonstrate the value of such targeted surveys, such as this one supported by the NRCP, especially when sampling is carried out strategically.

Conservation values. Few sites, apart from those in the World Heritage Area, were formally reserved within the parks system at the time the project was carried out (1990), although several sites are now specially protected forest reserves and so are not subject to logging. *Loc. 1* was gazetted in part to protect invertebrates, although only a corridor along the Savage River pipleline has been reserved; other tracts of forest in this region remain unprotected. *Locs 1* (Savage River), *6* (Big Sassy Creek) and *16* (Riveaux Creek) are unique in that a different pauropod species occurs on each and nowhere else. Riveaux Creek, just within the World Heritage Area, is the only site sampled with the rare rainforest tree, *Lagerostrobos franklinii* (Huon pine) and no *Nothofagus*. The reservation status of these three sites is relatively secure and not subject to logging but one important site for invertebrates, Simons Road, is subject to logging. This site should be designated as a protected forestry reserve.

Information on invertebrates from the NRCP survey has already provided the basis for special protection for several localities and all the twelve main localities, not formally protected by other legislation, were accepted for listing on the National Estate Register. With the enactment of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, however, land managers were no longer obliged to consult the register when assessing applications for developments on sites with native ecosystems. The recommendation from the NRCP 1990/1 survey was that *Locs. 1*, *2*, and *6*, not then protected, should be designated special reserves to provide for improved management of these sites for protection of invertebrate biodiversity. Since that time this has largely been achieved.

The conservation of Tasmanian rainforest is of high importance because it is only here that large tracts of it remain in Australia, most notably in the northwest (Anon, 2008).

Decisions on selection of reserves until recently has been largely based on vegetation and, in the RFA process, vegetational associations were given most weight (Anon, 1997). Because invertebrates integrate environmental variables at a finer scale than do plants and are more species rich, they exhibit a higher level of small scale endemism than do plants (Harvey, 2002). It has previously been noted that *Nothofagus* rainforest exhibits a higher level of generic diversity for Collembola than other vegetation types in the state (Greenslade, 1987) and the results of the NRCP survey emphasised this point. The species richness of invertebrates found in this vegetation type in Tasmania was estimated at around 750 (excluding two species rich groups, the Hymenoptera and Diptera) (Coy et al., 1993). Although only a proportion of the known fauna is reported in this paper (20%), the data illustrate their relevance to land management especially in decisions on formal reserves because invertebrates have an apparent high degree of endemism, even in a single forest type such as *Nothofagus* rainforest.

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Appendix 1

Species data on Arthropoda groups, excluding Pauropoda, from Tasmanian rainforests, included in this paper can be found on http://www.museumvictoria.com.au/About/Books-and-Journals/Journals/Memoirs-of-Museum-Victoria